



Investigating Technology Adoption Soon After Sustaining a Spinal Cord Injury

TAMANNA MOTAHAR , University of Utah, USA

JASON WIESE , University of Utah, USA

A spinal cord injury (SCI) typically results in a sudden change to an individual's motor function. People's adoption of technology soon after a severe SCI is crucial, since they must relearn most technology interactions to adjust to their new physical abilities and regain independence. This study examines how individuals adopt technologies soon after sustaining a severe SCI. By qualitatively analyzing the perspectives of ten rehabilitation clinicians, three individuals who recently sustained an SCI, and two of those participants' family members, we surfaced a spectrum of individuals' motivations to adopt technology post-injury and highlight the challenges they face to adopt technology. Our findings highlight the need to incorporate the holistic experience—including technology literacy, perception of support, and acceptance of the “new-normal”—in technology design for individuals who have a sudden change to motor functions. Our findings show that technology adoption is a critical component for the overall adjustment of post-SCI life. Finally, we use the extended version of the Technology Acceptance Model (TAM) to make recommendations for more inclusive assistive design.

CCS Concepts: • **Human-centered computing**;

Additional Key Words and Phrases: Spinal cord injury, rehabilitation, technology adoption

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1 INTRODUCTION

Individuals who sustain a spinal cord injury (SCI) undergo dramatic changes in their lives. Sustaining a severe SCI results in a wide range of impairments and disabilities, including impacts to sensation, motor control, breathing difficulties, and speech impairment [38]. These functional disabilities often necessitate using power-operated wheelchairs (PWC) and many other assistive technologies (AT). Suddenly losing one's functional abilities through a traumatic injury results in an abrupt change in one's life as one needs to learn to use technology differently than before (e.g., using mobile phones without finger dexterity). Recent ubiquitous computing research has examined AT design that compensates for individuals' motor disabilities and significantly enhances mobility and independence [1, 5, 33, 41]. Such technological assistance can augment or support a wide range of impaired body structures or functional abilities [1, 33, 41]. Regardless of the disability level, seamless adoption and integration are essential for users with disabilities to obtain the maximum benefit of ATs [18]. Therefore, a human-centered approach is essential to facilitate a smooth adoption of technology to improve the quality of life for individuals with disabilities.

This paper reports results from a larger ongoing project focused on designing ATs for and with people with a severe SCI. The findings from interviews with three patients from the Craig H. Neilsen Rehabilitation Hospital who had recently sustained a severe SCI, caregivers of two of these patients, and ten inpatient and outpatient

Authors' addresses: Tamanna Motahar , University of Utah, USA; Jason Wiese , University of Utah, USA.



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clinicians that we report here provide an answer to the following research question: **How do individuals adopt ATs soon after sustaining a severe SCI?** This includes the current practices and challenges of ATs adoption of people with severe SCI during three three-month inpatient rehabilitation hospital stays and three to six three-month outpatient periods after discharge [25]. Further, we observed an occupational therapy (OT) session wherein one patient participant learned to use the voice-to-text function on a mobile phone for the first time post-injury.

We began our data collection by interviewing the clinicians, subsequently following up with additional interviews with patients and caregivers and the observation session. This approach helped us to mitigate some of the well-known limitations in recruiting and involving individuals with a severe SCI in HCI research [38, 48], such as speech and breathing difficulties during interviews and contextual inquiries [52]. Further, when people with a severe SCI leave the rehabilitation hospital, it is both a crucial and challenging time as they adjust to a new life; engaging them in research during that time is very challenging, as we have seen in our other ongoing research. Additionally, retrospective data collection approaches after emerging from this critical time can lead to partial understanding because recall bias is amplified, especially during stressful times in one's life [34]. Despite these challenges, it was essential to get patients' own perspectives on their technology adoption.

Through the clinicians', patients', and caregivers' experiences, we surfaced new insights into the process of AT adoption and non-adoption and corresponding challenges during the rehabilitation period. We qualitatively analyzed all interview data and identified the motivations and challenges in adopting technology during rehabilitation. We also found that contemporary ATs do not explicitly accommodate the multiple and multi-level disabilities resulting from severe SCIs, and that regardless of the individual's motivation and challenges in adopting technology, clinicians assist them in adopting some technology to facilitate some degree of independence and safety. For people who sustain a severe SCI and lose many of their physical abilities, our findings provide the following contributions to ubiquitous computing and AT design:

- We identify a spectrum of technology adoption motivation among the intended users, including *non-adoption*, *partial-adoption*, and *successful adoption*, and describe these categories.
- We illustrate that the negative interactions individuals encounter with ATs during rehabilitation, due to its "one-size-fits-all" design, impact their overall adjustment to life after an SCI.
- We foreground technology adoption in the broader picture of people's adjustment to the "new normal" by contextualizing our findings in Venkatesh's extended version of the Technology Acceptance Model (TAM). [65]. This model focuses on the variables that influence the perceived usefulness of technology during adoption.
- We demonstrate that conventional personal informatics (PI) technology does not facilitate people's new self-tracking needs in their post-SCI lives. We highlight the need to explore and incorporate new tracking needs with appropriate interaction mechanisms to make PI technology more inclusive.

Our analysis provides a new understanding of the complex process of adopting AT, including people's motivations, challenges they encounter, and clinicians' roles in that process, soon after sustaining a severe SCI. The study emphasizes the necessity for future research in ATs and ubiquitous computing to address the unique needs of individuals with a severe SCI, to facilitate easier adoption and thus aiding their adjustment to post-SCI life with new physical abilities.

2 RELATED WORK

In this section, we discuss the literature to establish a foundation for our work by describing the importance of the rehabilitation period for the adjustment to post-SCI life (Section 2.1), illustrating contemporary ATs for people with motor disabilities (Section 2.2), establishing the importance of clinicians' role in the technology

adoption process during rehabilitation (Section 2.3), and finally, the importance of understanding technology adoption in a holistic manner (Section 2.4).

2.1 The rehabilitation period is crucial for coping with post-SCI uncertainty

SCI is a sudden, devastating, life-altering event that changes life dramatically [7]. People who sustain severe injuries—especially cervical injuries—lose most of their upper body function. With possible paralysis in their arms, hands, trunk, and legs, individuals may not be able to breathe independently, be unable to control bowel or bladder movements, and have reduced speech function [57]. They typically require assistance with activities of daily living, such as eating, dressing, bathing, and getting in or out of bed [44]. They also typically have less mobility in post-SCI life and may require PWCs with special controls.

Regardless of injury level, post-SCI life is unpredictable and full of uncertainty [46]. In a phenomenological study with 20 individuals with SCI, DeSanto-Madeya [24] revealed deep uncertainty in individuals' post-SCI lives: "Looking for understanding to a life that is unknown." As one of their participants explained:

The injury is just the beginning; so much happens afterward. You realize that there is osteoporosis, urinary tract infections, and bowel programs that don't work. It's one thing after the other. Just when you think you start getting even keel, you get hit with something else. ([24], page 273)

In order to cope with this uncertainty, the post-injury rehabilitation period is crucial to transitioning from one's status as a "patient" to that of an "individual with a disability". In a study of people who had recently sustained an SCI (6–8 weeks post-injury and at three months post-discharge from initial rehabilitation), Dorsett et al. [25] found that several perspectives such as planning, positive reframing, acceptance, and fighting spirit during the rehabilitation period help with this uncertainty of post-SCI life. Therefore, how individuals see themselves and their lives during the rehabilitation period—immediately after the injury—critically impacts the rest of their lives.

2.2 Technology helps the transition, but technology adoption soon after injury is not well explored

After sustaining a severe SCI, most individuals cannot use technology the same way they used it before the injury, mainly because of the dominant role that hands and arms play in input techniques, such as touch screens, computer mice, and keyboards [44]. Thus, individuals need to relearn interactions with technology that differ from their previous experience. Prior clinical research has demonstrated that AT positively contributes to the lives of people with an SCI, helps to reduce the impact of impairment, and improves their quality of life [2, 16, 28]. Additionally, researchers stressed the need for ease of use when using ATs to instill confidence in users [16]. Notably, Atkins and Fowler Davis [2] conducted a systematic review of research on community-dwelling individuals (not in the rehabilitation hospital) with severe SCIs. They used the Technology Adoption Model (TAM) to evaluate their technology adoption. Although the review explored the experiences of successful ATs users, it falls short of exploring the challenges of adoption or reasons for non-adoption due to recruitment limitations: most of the studies used purposive sampling. It, therefore, may have reduced the number of patients who were non-[technology] adopters.

People with upper-body motor impairments use various alternative input modalities (e.g., voice control, eye gaze), to control mobile devices [14, 39], perform text entry tasks [62], interact with TV, or play games [30, 64]. Li et al. [44] described that people with upper body impairment leveraged ATs in their activities of daily life (ADL) (e.g., dressing, bathing, toileting, driving). Four of their 12 participants acquired upper body impairment through SCI, and others through a stroke and chronic neurological diseases such as cerebral palsy, muscular dystrophy, primary lateral sclerosis, and arthrogryposis multiplex congenita. Chronic neurological conditions progressively impact one's mobility and functionality, where individuals adopt their new abilities with the progression of the disease. In contrast, SCI and stroke cause sudden impairment. Therefore, in the acute stage or the rehabilitation period soon after sustaining a traumatic incident (e.g., a severe SCI), people need to adjust to many activities

that they previously conducted with their hands and arms. Thus, although AT enables people with upper body impairments to interact with technology independently, we do not yet know how individuals with an SCI initially learn and adopt those technologies.

2.3 Clinicians' roles in helping individuals adopt technology immediately after an SCI

Prior HCI research also reported that clinicians play a crucial role in evaluating people's changed abilities and prescribing suitable ATs during the rehabilitation period [11, 35, 45, 58]. For instance, Li et al. [45] discussed that during a clinical assessment of upper extremity abilities, a clinician — typically a physical therapist (PT) or occupational therapist (OT) — assesses a wheelchair user's daily routines and therapy goals, using measurements including targeted evaluation of range of motion, muscle strength, and sensory function. Thus, clinicians are deeply involved in the processes of their patients' technology acceptance, adoption, and utilization in the early days after sustaining the injury.

Research has also explored the efforts of OTs and PTs to fabricate ATs according to the target user's specific needs, embedding digital fabrication into their usual client-care process to make technology more acceptable [35]. However, there is a tension between the potential benefits of such clinical digital fabrication and concerns about its adoption in clinical practice [36]. More generally, although clinicians might be inspired to develop novel approaches and custom solutions to support their patients, little is known about how users adopt those technologies in a clinical setting, particularly soon after sustaining a severe SCI.

2.4 Technology design in the intersection of disability studies and accessibility research

Accessibility research has leveraged work from disability studies [50] to build a more inclusive society for people with disabilities. In the discourses of disability theories, disability is often described through the medical model: *physical/sensory functions, limbs, health, or cognitive ability loss* [66] and through the social model: *removing social barriers and mitigating functional limitations* [32], respectively. However, both of these models of disability fall short of fully describing disabled experiences: the medical model is deeply oppressive, focused on “fixing” a person, and leads to segregative societies [59]— technology designed with this philosophy fosters this segregation. In contrast, the social model of disability is useful in activism but not comprehensive—there are many aspects of disabled experiences where barrier removal efforts will not create equal experiences [29, 32]. To bridge between these, researchers have adopted the discourse of “critical realism” [29, 49] where disability incorporates societal, medical, and intellectual policies and rhetoric related to disabilities. Through that lens, people's interactions immediately after acquiring the injury affect how they holistically adjust to their post-SCI lives. As “technology use does not happen in a social vacuum,” [60] adjusting to post-SCI life is intuitively connected with post-SCI technology adoption. Therefore, HCI researchers need to examine individuals' technology adoption from an integrative perspective in order to ensure a successful transition to post-SCI life.

In this work, we investigated people's technology adoption in the rehabilitation hospital, soon after sustaining a severe injury, through the experiences of rehabilitation clinicians, patients, and caregivers.

3 METHODS

This paper reports results from a larger project focusing on designing ATs with and for people who sustained severe SCIs and use PWCs. As a part of that project, we conducted semi-structured interviews with ten clinicians (inpatient and outpatient) who work with the target population. Later, we interviewed three individuals who were inpatients in the rehabilitation hospital and had recently sustained an SCI. In two of these interviews, caregivers participated alongside participants who acquired speech impairments due to their injury. Additionally, we conducted an observation session in which an occupational therapist delivered AT training to one of the patient-participants. We provide details of our methods below.

3.1 Data collection

3.1.1 Recruitment. Our recruitment process started in 2021. We used word of mouth to recruit ten clinicians (see Table 1), including physical and occupational therapists (PTs and OTs), patient educators, and a physician, who all work in an SCI unit of a rehabilitation hospital. We sought to include both inpatient and outpatient clinicians to obtain their perspectives on individuals' technology adoption soon after sustaining a severe SCI. We operationalize the concept of "soon after" as the time frame of rehabilitation, including three months of inpatient rehabilitation stays and six months after discharge [25]. We focused on clinicians who work with individuals using PWCs because the ability to use technology substantially differs between PWC and manual wheelchair users. We received verbal consent from each clinician-participant, following an approved IRB protocol.

Simultaneously, we attempted to recruit recently discharged patients to conduct interviews with them to understand their experiences and perspectives on technology adoption. However, during this time, we were unable to recruit a single participant using this approach. Despite confirming interest in participating before discharge, most potential participants did not respond to further communication. We believe these difficulties relate to all the challenges and adjustments inherent in the "soon after" period. Later, during the summer of 2023, we changed our strategy and successfully recruited three patient participants (see Table 2) out of five whom our clinician participants referred, all of whom we refer to with pseudonyms. Two of these participants—Alex and Cole—have severe speech impairments. Additionally, we invited the patients' caregivers to participate in the interviews so they could share their perspectives on the patients' adoption of technology. Both Alex's father and Cole's mother agreed to participate in the interviews. We received consent from each patient-participant regarding their own and caregivers' participation in the interviews. Additionally, George gave us consent to observe one of his OT sessions. We also received consent from the OT who was conducting the OT session. All interviews with patients and caregivers were in person, and we audio recorded the interviews. All participation was voluntary, and no compensation was provided to the participants. Our study protocol was approved by our Institutional Review Board (IRB).

3.1.2 Recruitment limitations. We acknowledge the limited participation of individuals with a recent SCI despite significant efforts to recruit these individuals. Here, we refer to the extensively documented challenges associated with recruiting participants who have severe or multiple disabilities [38, 48, 52]. Research with these individuals encounters numerous obstacles, and the pool of potential participants is relatively small, particularly for those who have recently sustained severe SCIs. When we found our initial recruitment efforts to be unsuccessful, we pivoted to understanding the perspectives of the closest allies—clinicians in the rehabilitation hospital—who play a pivotal role in these individuals' technology adoption process. Subsequent efforts to recruit from the inpatient population allowed us to explore the firsthand experiences of three individuals who recently sustained a severe SCI and their caregivers, substantiated by the OT session observation data. As suggested by prior literature [38], even this small number of participants represents essential perspectives that are difficult to obtain and are currently unreported in the literature.

3.1.3 Semi-structured interviews with clinicians. During the interviews, we asked clinicians questions about their experiences with individuals' ATs adoption during the rehabilitation period. We focused on clinicians' views on people's motivation, practices, and challenges to adopt technology; the questions are available in supplementary material. We asked participants to recall and describe examples of different adoption processes (e.g., examples of adoption/non-adoption) they have encountered during their years-long experience of working with this population. These examples helped us to understand their perspectives on the broad spectrum of technology adoption by individuals with severe SCIs. We asked clinicians nine questions in total. Among them, two questions were related to patients' learning of pressure relief behavior in the rehabilitation hospital, thus irrelevant to this paper, and are not included in the supplementary material. We conducted interviews in-person or over Zoom [67]

Table 1. Characteristics of our ten clinician-participants. We spoke with two OTs, five PTs, two patient educators, and a physician.

Clinician participant	Specialization	Stage of rehabilitation (inpatient or outpatient)	Years of experience working with people with a severe SCI during rehabilitation
C1	Occupational Therapist	Inpatient	5 years
C2	Occupational Therapist	Inpatient	Three months
C3	Physician	Inpatient	22 years
C4	Patient educator	Inpatient	16 years
C5	Patient educator	Inpatient	9 years
C6	Physical Therapist	Outpatient	28 years
C7	Physical Therapist	Outpatient	13 years
C8	Physical Therapist	Inpatient	9 years
C9	Physical Therapist	Inpatient	11 years
C10	Physical Therapist	Outpatient	9 years

Table 2. Demographics, and pre-injury technology experience of three patient-participants including the relation with their caregiver who participated in the interview; *both Alex and Cole have speech impairment, and neck injury

Patient participant (Pseudonym)	Age, Gender	Duration since injury	Injury level	Pre-injury tech-experience (in the scale of 1 to 5) phone-computer	Caregiver present during interview
Alex	23, Male	Three months	C5*	5-5	Father
Cole	18, Non-binary	Three weeks	C6*	3-1	Mother
George	56, Male	Six weeks	Cervical	5-4	NA

video calls according to their preferences. The average interview duration was 30 minutes (ranging from 23 to 43 minutes), and we recorded the interviews with participants' consent.

3.1.4 Semi-structured interviews with patients and caregivers. All three interviews with patients were in-person, with an average duration of 20 minutes (ranging from 18 to 21 minutes). During the interviews with patients and their caregivers, we asked about participants' previous experiences with technology, the specific types of new ATs they received training on in the rehabilitation hospital, and the most challenging technologies they encountered. The caregivers who participated provided additional insights into the challenges faced by the participants based on their observation of the technology adoption process. They also shared their opinions on ways the technology might better serve their child.

3.1.5 Observation of OT session. During George's OT session, he was learning to use a mobile phone for the first time since his injury. According to his OT, George initially refused to use the mobile phone during the initial six weeks due to grief, physical pain, and emotional instability. However, in the sixth week, he expressed an interest in learning to use the mobile phone. George consented to be observed.

During the session, George was first introduced to a customized stylus to operate the phone with his limited hand functionalities. Later, the OT introduced him to the voice-to-text feature to operate his mobile phone. This session was 30 minutes long. We occasionally asked clarification questions to both the OT and George and collected field notes.

3.2 Analysis

We transcribed all interviews using an automated transcription service (Otter.ai [54]). We then employed reflexive thematic analysis [4] to analyze transcribed interview data and observation field notes. We started by reading through the interview transcripts and performed open coding of the transcripts and field notes in Atlas.ti [3]. Our coding was focused on identifying codes that accurately capture the content of the raw qualitative data. Example codes include: “not tech-savvy”, “fatigued with eye tracking”, “voices are not strong”, and “positioning of phone.” One author coded the data and progressively discussed the codes with the other author. This process resulted in a total of 363 codes from the 10 interviews with the clinicians, 177 codes from the three interviews with patients and caregivers, and 27 codes from the observational data. The codes that stemmed from the two questions from clinicians’ interviews—not relevant to this paper—are excluded here. After finishing the coding, the codes were transferred into a Miro [51] board, and the authors worked together to create an affinity diagram. Because of our initial inability to recruit individuals with SCIs directly, we first developed themes based on the clinicians’ data. Later, we revisited the original themes with the additional codes from the patient interviews and observation session.

Throughout this process, the researchers discussed the initial codes extensively and reviewed, grouped, and regrouped the codes. Then, we created code groups that reflected all clinicians’, patients and caregivers’ perspectives. We created a total of 44 code groups, for example, ‘independence as a motivation’, ‘failure impacts self-efficacy’, ‘clinicians ensure safety’, ‘positioning of the phone is crucial’, and ‘error fixing is hard’. The list of the code groups are provided as supplementary material. After several rounds of iteration, we finalized two themes that answer our particular research question for this paper.

3.3 Limitations

There may be different motivations and challenges for individuals to adopt or not adopt available ATs in the rehabilitation period depending on different contexts (e.g., geographical location, language, financial situation) that were not captured in this study. Our study was situated in a USA-based rehabilitation hospital; therefore, we acknowledge that the concept of rehabilitation and also the clinicians’ and patients’ perspectives might vary in other countries. This study also heavily relies on clinicians’ retrospective recall and summarization, which is known to result in imperfect data. We took steps to mitigate this effect by asking clinicians to recall and describe specific examples. Additionally, our interviews with patients and caregivers corroborated many of the points made by clinicians, which increases our confidence in the validity of the data we collected.

4 FINDINGS

Our findings draw from the years-long experience of our clinician participants, and the firsthand experiences of patients and caregivers. These insights shed light on the diverse factors influencing technology adoption soon after a severe SCI, encompassing both the challenges and motivations for (not) adopting technology. We discuss our findings below.

4.1 Conventional ATs are not well suited for adoption soon after a severe injury

While clinicians help individuals learn about and how to use ATs depending on the level of disability they acquire, the available ATs are not always well-suited for adoption soon after sustaining a severe SCI. This section illustrates the types of technology clinicians prescribe and the incompatibility between the available ATs and the nature of some people’s disabilities after sustaining a severe injury.

4.1.1 Clinicians offer ATs according to individuals’ level of injury. Individuals with severe SCIs are prescribed different ATs and technology interactions by clinicians at the rehabilitation hospital according to their level of injury. According to our clinician-participants, individuals with severe injuries, such as cervical injuries, need to

learn how to control PWCs so they can use them to get around. Clinicians assess the user's ability and deploy a suitable interaction mechanism (e.g., joystick, head control, chin control, sip, and puff) for the person so that they can control the wheelchair by themselves. For instance, to operate a PWC with a joystick, individuals need a certain amount of strength in their arms, wrists, and fingers. Otherwise, clinicians might modify the controller using 3-D printing to make the interaction easier for a user. As C5 explained:

...sometimes [if] patients have enough function with their hand, they can drive with one of our 3-D printed magnet joystick things... And [if they do] not [have] the strength or they can not push up [the joystick] against gravity, maybe [then] they are only driving with the chin control. [Or] there are buddy button [that] can just always be on the chair so that they have a way to just hit them [to tilt] back. (C5, Patient educator)

Thus, clinicians assess patients' functional capability and prescribe a suitable controller, such as a 3-D printed magnetic joystick controlled by the hand or fingers or a controller operated by the user's chin.

Additionally, clinicians help individuals to re learn how to use mobile phones and tablets with their new abilities. For instance, inpatient OTs try different phone mounts so the patient can see and use their phone without holding it. Different mechanisms are available to control the device, including voice control, head mouse (e.g., glassouse¹), or sip and puff to interact with the phone. C1 shared how they prescribe ATs to facilitate smartphone usage:

... the most common is probably voice control. It is emerging, and it is getting better. It is still not perfect, but that is probably the one that works most consistently from across iOS to Android. Then there are also options to use sip and puff, which is tricky but doable. Then, the switch, where they press a switch either with their head or with their hand to stage cycle through options. And then there are other options too, like, you can wear a wearable Bluetooth mouse that fits like a pair of glasses [glassouse] [...], but I would say if you are not using your hands, it is probably voice... (C1, Inpatient OT)

Additionally, clinicians may introduce gaming controllers to individuals with SCI for rehabilitation purposes. C2 highlighted the introduction of diverse gaming controllers to enhance user comfort with ATs:

I worked with one person who was quadriplegic [PWC user] and he was really young[...] he was set up with some adaptive gaming. And he really liked the outcome of it. (C2, Inpatient OT)

4.1.2 ATs are not always accessible to people with a severe SCI. Emphasizing the different levels and multiple types of disabilities individuals acquire after sustaining a severe SCI, all participants expressed issues with the utility of available ATs in the rehabilitation hospital. For example even people with the same level of injury cannot use similar accessibility features. C5 describes this:

...it is the snowflake injury, because everyone looks a little bit different. And it is true, everyone presents just a little bit differently, even though there could be two people with C5 [the same level of cervical injury], you know, they might not look the same. (C5, Patient educator)

In addition, it requires considerable physical and cognitive strength for an individual with a recent severe injury to interact with ATs, including voice or mouth-based control (e.g., sip and puff). Individuals' voices are often not strong enough or loud enough soon after a cervical injury, or they have difficulty breathing, making it difficult to use voice controls. All patient-participants who initially received training on voice-to-text for operating their phones experienced that challenge. As Alex and his father elaborated:

*My voice was pretty tired when I first used it [voice-to-text for operating phone]. (Alex)
...the first month he (Alex) had a tracheostomy (a procedure to help air and oxygen reach the lungs by creating an opening into the trachea from outside the neck) due to the SCI, so he could not talk. So if you*

¹<https://glassouse.com/>

can not talk and you can not move your arms, none of the technology is accessible. So until he got it off, his voice is really soft and it was hard. (Alex's father)

Alex's father also mentioned that to be loud enough for the phone to detect his speech, Alex felt like he was yelling. Likewise, during the session we observed, George received training on voice-to-text. He encountered difficulties with voice commands, needing to repeat words, raise his voice, and frequently position his face close to the phone to activate the commands. Additionally, George had to strain his voice to ensure audibility, which led to fatigue.

C8 noted that individuals also become fatigued due to the physical effort required to engage in head tracking or eye gaze interactions. C8 discussed their experience with an individual who fatigued quickly while using eye gaze interaction and could not deal with the additional stress associated with the new interaction technique. In addition, that individual could not use voice control because they had lost their speaking ability due to the injury. Therefore, the individual could not use the available AT features despite being interested.

Another major challenge for patients lies in unlocking their phones. For example, with Cole's neck collar on, it was difficult to use face detection to get access to the phone. They can still enter a password with minimal use of their thumbs, but they reduced the length of their password to simplify the process:

...the face ID, especially with my collar. If it [phone] is not like up high in my face, I gotta input my password. I actually change my password from a six digit to a four digit just so it is easy to put in. I almost thought about just taking the password off. I still might. (Cole)

Likewise, George faces challenges when using voice commands to enter his passwords. He shared that he says the password "quietly" to protect privacy when there are people around him.

Thus, all participants agreed that available ATs cannot accommodate the wide range of capabilities that individuals acquire soon after a severe SCI. C1 illustrated:

...the problem with accessibility features and accessibility tools and technology is that it is not built from the ground up with varying levels of ability in mind, a lot of times, these are purpose built devices that are made for somebody who doesn't have a difference of ability. So I think...the technology is not intuitive. It is not particularly easy to use. (C1, Inpatient OT)

4.1.3 Complicated set-up process and troubleshooting make individuals dependent on caregivers and clinicians. Our clinician participants reported that individuals with newly acquired disabilities typically cannot setup technology or do troubleshooting independently because those processes are either not accessible or are quite cumbersome; thus, they rely on assistance from caregivers or clinicians for these tasks.

For instance, using a PWC to perform self-care activities, such as performing pressure relief using the chair's tilt function, requires sufficient strength in the arms and hands to control the joystick; otherwise, individuals must rely on caregivers or clinicians for assistance. C4 shared their experience with a patient who could push the joystick back for tilting but not up to get back to a straight position, so a caregiver had to assist them.

Similarly, all patient and caregiver participants found learning to handle the PWC joystick, becoming acquainted with the buttons to modify chair modes, and adjusting settings for speed, tilt, and reclining particularly challenging. Alex's father explicitly noted the vast array of wheelchair options as confusing and requiring additional physical and cognitive effort to remember and operate. This complexity could be eased by providing more straightforward buttons for adjusting settings:

...one of the challenges, you see that control [the chair], ...but it has eight or nine settings. So every time you have to go from one setting to another, [Alex] got to manually go through nine settings, to get to the one or two that he needs, what would be helpful is to just adjust it to you need to tilt back, you need to tilt forward and you need to go, that's it. (Alex's Father)



Fig. 1. An example of the number of buttons needed to control the tilting of a power wheelchair

Similarly, Alex's father reported an incident where Alex's phone mount broke, rendering the phone unusable for him. Alex's father had to repair it, as Alex was unable to use the phone without the holder.

Learning PWC speed and directional control poses another challenge, primarily because most patients have limited hand functionality, making it difficult to use a joystick optimally. Cole's mother highlighted that while Cole managed to grasp joystick control within a week, maneuvering the joystick for entry and exit from elevators remains challenging due to Cole's limited hand functionality. This challenge arises from the difficulty in maintaining a balance between "dexterity" and "steering ability", necessitating significant cognitive effort to determine when and how to halt the wheelchair. During the six-week rehabilitation period, George learned how to maneuver the wheelchair; however, due to the complex buttons for tilting and reclining, he opted to change his entire wheelchair. Later, he received a customized PWC equipped with a simplified single button for tilting and reclining.

Similarly, to use voice control or setup the voice control application on the phone, there are many initial steps to perform. Cole noted that positioning the phone is crucial to ensuring the commands work correctly, and they needed assistance to position it. Alex's father also pointed to the need for the phone to be positioned very close to Alex due to his speech impairment, ensuring that his voice reaches the phone effectively:

this [mobile-mount] will go on [...]those wheelchair(s) or his bed and you hook your phone into it. But if it is not set up correctly, where you can see it or talk to it or hear it. We had challenges with this use of equipment. (Alex's father)

Alex's father elaborated that, even when Alex is in bed, turning Alex every two hours is necessary to prevent pressure ulcers. Consequently, the phone's position needs to be adjusted accordingly. Having no permanent caregiver, George thus decided not to attach the phone to his PWC or bed. Instead, he prefers to keep it on the table and use it only when it is absolutely necessary.

Clinician participants corroborated that individuals with newly acquired injuries become frustrated if the phone, which they use to control many aspects of their environment, falls off the wheelchair and that it is challenging for individuals with limited hand functions to reset, recharge, or fix technologies independently.

During the observation session, we found the phone fell off on George two times as he was learning how to use voice control. Alex's father noted a similar concern with tablets:

you could do the same thing with an iPad, but it is really heavy. And so if it is not really tight, attached to the bed or the chair, it will fall and hit him in the face. And so having that, you know, accessible has just not been practical. (Alex's father)

Therefore, although individuals attempt to adopt technology, the complicated setup and troubleshooting process can lead to disappointment or frustration and can impede the adoption of ATs.

4.1.4 Assistive technologies take more time than previous technology experiences. Our clinician-participants also observed that the responsiveness of ATs is slower and less reliable than traditional input methods. Further, the steps necessary to correct errors take longer and cause users frustration. For instance, clinicians found that individuals with limited hand functionality often needed to correct errors while using voice-to-text functions since the words that are recognized are not always accurate:

...patients find that it [voice-to-text translation] is not as accurate as it could be and it ends up taking them longer because they have to go back and fix errors. (C9, Outpatient PT)

Further, clinicians indicated that individuals with a newly acquired disability find it challenging to respond to an email or text message quickly or to write a more detailed response using ATs; it is more difficult for people who are used to typing email responses or texts using their fingers over their phones, and they become frustrated by this cumbersome and slow interaction process:

... it is pretty easy to like, open an email and read an email, using voice or the glassouse. But if you want to respond to an email quickly, and to be able to type and surf the internet fast, it is not very fast. It is slower to access than it is when you have two thumbs, you can just move through things. (C7, Inpatient PT)

Additionally, George shared that voice commands may inadvertently capture surrounding noises, such as TV sounds or conversations, leading to frequent command errors. Consequently, correcting errors in text using the voice-to-text function can be particularly challenging. George noted that using backspace via the voice command to fix errors stemming from surrounding noise was difficult. Likewise, Cole shared that they ended up deleting the entire text if an error occurred and tried again. Further, we found that the longer response time discouraged George from using the voice-to-text function. During the OT session, when George was instructed to type a text to his son using voice commands, it took him a minute to input three words, which made him overwhelmed. Ultimately, he opted to discontinue the session.

4.1.5 No tracking technology available for post-SCI health activities. Although our patient-participants were not involved in any health-related tracking pre-injury, clinicians recalled that some individuals were highly involved in tracking many health-related activities before their injury. After sustaining an SCI, they had to abandon self-tracking practices due to the incompatibility of tracking features and interactions with available tracking technologies. Although some tracking needs (e.g., tracking heart rates or food journals) remain the same, individuals no longer have the same ability or physical strength to utilize the same technology. Also, after an injury, individuals must perform several self-care activities; much of their time is occupied with learning and performing those new tasks, which take precedence:

... a lot of those behaviors really pause while they are in the hospital because just everything is so different than [before], so hard to just do your day to day tasks that those extraneous, things get peeled off. (C8, Inpatient PT)

Instead, individuals often discover the requirements for tracking their new self-care activities during rehabilitation, including bladder management, pressure relief, fluid control, medications, and blood sugar control.

Clinicians stated that some individuals have expressed interest in independently tracking their bladder activity, nutrition, or pressure relief, but they have not found tools designed for these tasks. Our patient and caregiver participants echoed that they do not use any tracking tools to monitor those activities and rely entirely on nurse's reminders:

the nurse is the one that checks how often you have cathed or whatever. But, I could see that if you did not have all of that support. There might be a need for it [tracking tool]. For sure. So that you would maybe set a timer that says I need to cath in 20 minutes or something. (Cole's mother)

Some clinicians ask these individuals to remember these new activities by setting a timer or phone reminder. However, some people are resistant due to the overwhelming number of new activities. Alex's father corroborated this:

...it takes so much time to try to log all that in and do whatever needs to be done next. It is an overwhelming task, just to take care of the needs at hand, that having that added thing that you got to track every single thing that you are doing...if you are trying to track every single thing [activity]... there is not enough time. (Alex's father)

Clinicians also caution that reminders for so many activities will confuse and overwhelm individuals in their rehabilitation period:

...I have never suggested an alarm for cathing. And I guess it would be confusing to have multiple alarms like, Oh, what was that for my pressure release? Or my cathing? (C4, Patient educator)

Further, clinicians said that they do not recommend that individuals rely entirely on technology for remembering self-care activities. One reason is that if they rely on technology that stops working or has an issue, they will be less able to handle it independently. Furthermore, fixing issues with technology after hospital discharge is not a straightforward process. Although clinicians assist individuals with troubleshooting technology while in the hospital, it would be challenging after discharge since individuals may not know who to contact for assistance once they have left the rehabilitation facility.

4.2 Individuals' Motivation to Adopt Technology Varies Widely

In addition to the challenges using ATs described in the previous section, patients also appear to have different baseline levels of motivation to use technology, which also impacts the technology adoption process.

4.2.1 Motivation varies depending on age, tech-savviness and prior experience. According to clinicians, age, prior experiences, and tech-savviness are all crucial deciding factors in people's willingness to adopt ATs. For instance, clinicians shared that individuals who were frequent phone users pre-injury are often highly motivated to start using them again post-injury. Likewise, we found that all three patient-participants were frequent phone users before their injury and were eager to re-learn how to use mobile phones during rehabilitation. Despite losing the ability to hold or operate the phones with their hands, they are nevertheless eager to resume using those devices.

While not exclusively determined by age, clinicians mentioned that younger people tend to be more tech-enthusiastic or dependent on their phones and are thus more eager to get back to their phone usage. Similarly, we found that Cole, the youngest participant, was more tech-enthusiastic and tried to figure out their phone set-up quickly. Cole's mother described Cole's tech enthusiasm:

...I was here on the first day that it was happening [challenges to set-up voice control]. [Cole] was getting a little bit frustrated, [but Cole] had it figured out. [Cole] knew which commands to give to it, and changed things enough that it was easier. (Cole's mother)

Further, individuals who intend to return to work or resume their education post-rehabilitation also demonstrate enthusiasm to embrace new technology and adopt ATs relatively quickly. However, clinicians perceived individuals

with less prior technology experience to be less motivated to learn how to use ATs and to struggle with it once they do.

Clinicians also shared that many patients they had worked with came from rural communities, had less prior experience with technology, and were less willing to adopt it during rehabilitation. C5 explained that these people may not have had much of an opportunity to use technology pre-injury, even for communication purposes (e.g., having an email address), and instead might only rely on phone calls. That lack of familiarity with technology might make them reluctant to adopt any technology features post-injury:

people from very rural places who are not necessarily interested [to adopt technology] ... Like, when we set up people with MyChart [electronic medical record], they are like, "I do not have an email address."
(C5, Patient educator)

With such little prior exposure to technology, these individuals focus more on regaining their lost physical functions:

Some patients are like, 'I do not want to learn this' or ... 'I never used a smartphone before, why am I going to start using [one now]' (C5, Patient educator)

Thus, prior experience is a crucial defining factor of an individual's motivation to adopt ATs.

4.2.2 Desire to be independent plays a role in adopting technology. Individuals' desire to be independent is another crucial motivating factor of technology adoption; using smartphones or social media to communicate, answering emails through a phone or iPad, watching videos on YouTube, or controlling smart home functions are all tasks that motivate people when adopting technology. C2 shared that individuals use the iPad in the rehabilitation hospital to independently control room functions like the lights or TV of a smart patient room [22, 23]:

...they're [technology-adopters] usually really receptive to the iPads in the room, using that technology to control lights and blinds, and things like that. Usually, it is the environmental controls that they like, easy to adopt, ...when they can see a change when it makes their life easier right away. (C2, Inpatient OT)

Similarly, one of the first pieces of technology introduced to individuals is the PWC to facilitate independent mobility. Patient-participants mentioned receiving their PWC and training during the first week of their rehabilitation stay. Learning to operate a PWC is a time-consuming and intricate process; however, they needed to adopt it as it is the only means of mobility in their post-injury life, and clinicians try their best to make it compatible. For instance, George wanted to adopt the PWC; clinicians helped him to try all possible options for interaction with a chair. Finally, they changed the chair and gave George a totally new interaction (button-control) to facilitate his mobility independence. Thus, although adopting the PWC is complicated at the beginning, individuals work to learn how to operate the PWC to maximize their mobility in their post-injury period.

In contrast, individuals who are not enthusiastic about adopting technology typically rely on their families and friends to complete tasks for them, reducing their independence. For instance, family members and caregivers help these individuals to login to their email or social media accounts and to control the smart room technology around them.

Nevertheless, clinicians strive to teach some basic technology features to individuals—unwilling to adopt technology—to have at least some independence. C5 shared:

...we are trying to help them to be as independent as they can be... normally over time throughout the rehab, we can [...] educate them enough that they hopefully see the benefit to at least some sort of utilization...and they are probably not the people that are going to be searching the internet and writing an email. But they might like to use it for very basic things. (C5, Patient educator)

4.2.3 Not accepting the “new normal” demotivates technology adoption. Another critical obstacle to technology adoption during rehabilitation is the reluctance to accept the “new normal”—they are not mentally or emotionally prepared to accept their new set of physical abilities for the rest of their lives. This rejection of reality leads them to decline to adopt new ATs or other features. Clinicians mentioned that accepting the “new normal” can take a while for some people:

...there is a certain amount of healing and mourning that goes into just accepting your new life and your new body and your new injury. And that is usually not complete by the time you leave inpatient (C1, Inpatient OT)

George’s reluctance to learn phone usage during the initial six weeks of his rehabilitation hospital stay also underscores the perspective that he was not prepared to accept the new reality, which he mentioned explicitly during the observation session. Further, C3 highlighted the need for a sufficient rehabilitation hospital stay to adjust to their “new normal”, as this stay duration significantly influences the acceptance of reality, allowing individuals to habituate and adapt various aspects of their lives. The sheer volume of information and tasks they must learn can overwhelm and confuse newly injured people:

In Europe, the average length of stay for spinal cord injury is six-to-12 months. And here [in the US], in the rehab center is one-to-two months. And so it is such a dramatic difference. I think that our patients are truly overwhelmed. Like, they are just overwhelmed with information. And they are not sure which things are important or not, I think they have a hard time prioritizing (C3, Physician)

Similarly, C1 stated that many individuals cannot learn and adopt the technology within the short period of rehabilitation, and they do not force them to do so:

...a couple of weeks of somebody’s injury, they have had some exposure to technology, assuming that they are appropriate for it and appropriate as determined based on just cognitive function and then desire. I am not going to force someone to use technology if they do not want to. (C1, Inpatient OT)

Instead, clinicians encourage technology non-adopters to learn some of the technology features to ensure safety during incidents like falls or medical emergencies. OTs assist individuals in using fall-prevention bracelets or phone applications to get help in case of a fall when they are alone in the hospital. Clinicians also assist them in adopting some technology features if they plan to live alone post-rehabilitation. C2 shared such experience:

There was one individual... he was going home alone...so I recommended something like an Alexa to set up in his home. He was also very low tech and did not even have an email or anything...I was trying to help him set that up...And he was pretty resistant to it, hesitantly learning and going along with it with me. But, he was only going to use it for safety. (C2, Inpatient-OT)

In this way, adopting technology after sustaining an injury is highly dependent on accepting the “new normal” and getting used to their new abilities.

4.2.4 Using technology requires a certain level of cognitive ability. Our clinician-participants believe good cognitive conditions are essential for navigating ATs. Individuals with cognitive impairment—whether due to their injury or independent of it—may have difficulty following technology instructions. Additionally, even if the SCI does not directly impact an individual’s cognitive condition, there can also be second-order effects from pain medication, sleep deprivation, or complications associated with the hospital stay that can affect their cognitive abilities. C8 stated:

...and their main thing was like cognitive issues...they just were not quite understanding kind of the guidelines that we were giving them to access it [glassouse] ... Like, if somebody is not cognitively intact, it is hard for them to navigate this new way of using a piece of technology they are not previously familiar with. (C8, Inpatient PT)

Thus, soon after sustaining the traumatic injury, individuals may struggle to learn how to use ATs because of their cognitive state.

4.2.5 Failed attempt or not anticipating the need for technology in the post-rehabilitation period. According to clinicians, failed attempts or negative experiences with ATs rapidly demotivate individuals to adopt AT during rehabilitation. These negative experiences or unsuccessful attempts leave individuals feeling incompetent. When less tech-savvy individuals experiment with prescribed ATs initially, the outcome of those efforts can impact their adoption. Early success boosts confidence and leads toward future adoption, while failure or challenges—such as physical strain—result in doubt, feelings of incompetence, and permanent abandonment of the technologies. As C3 elaborated:

I think it is more fear, intimidation, feeling stupid, maybe that they can not use the technology that they know other people... know how to use. (C3, Physician)

Likewise, during the OT session, we observed that George faced difficulty holding and using the stylus due to his dexterity. Specifically, when instructed to touch a specific point on the screen to open an application, he struggled and inadvertently touched different spots, leading to the unintended opening of a different application. The high screen sensitivity resulted in the unintended opening of a different application; this left him disheartened and uninterested in using the custom-made stylus for the phone.

In addition, some individuals hesitate to learn new technologies during rehabilitation because they cannot anticipate their value or future needs. Trying to teach technology to a non-tech enthusiast, C2 realized that the individual did not understand its future importance:

The Alexa I had set up was only for safety. So if he did have a fall, or did need something, and he needed to call somebody, and he did not have his phone with him, he could use Alexa. And to him, obviously, in his mind, he is not thinking about having phone calls or having emergencies. (C2, Inpatient OT)

Overall, despite a wide range of challenges and motivation, clinicians try to help individuals learn some technology to adjust to their post-SCI life. Thus, these challenges and motivations are indispensable to help researchers working with ATs to design more effective and useful technology.

5 DISCUSSION

In this work, we respond to a call by the HCI and accessibility research communities to adopt the lens of critical reflection of disability theories [49] to investigate the holistic perspectives of people’s technology adoption who recently acquired severe disabilities due to an SCI. To do so, we sought the perspectives of rehabilitation clinicians, individuals who recently sustained a severe SCI, and their caregivers. This effort revealed a broad spectrum of individuals’ technology adoption and related challenges during this critical time window of rehabilitation [63].

5.1 Clinicians perceive patients’ motivation to adopt technology to vary from person to person

Our findings in Section 4.2 revealed that the clinicians we interviewed see their patients as having a range of motivation levels to adopt ATs soon after sustaining a severe SCI, covering the spectrum of *non-adoption*, *partial-adoption* and *successful adoption*. In Figure 2, we present the synthesis of clinicians’ perspectives on individuals’ technology adoption.

From our synthesis, individuals who are at the **low motivation to adopt ATs** side of the spectrum fit one or more criteria from the following; they are: (1) older adults or from rural places and have little to no prior experience with technology (Section 4.2.1); (2) believe their lost abilities will return (Section 4.2.1); (3) predominantly or entirely rely on caregivers/family members to accomplish tasks (Section 4.2.2); (4) not yet ready to accept the “new normal”—their new set of abilities (Section 4.2.3); (5) cognitively impaired due to injury or other treatment-related

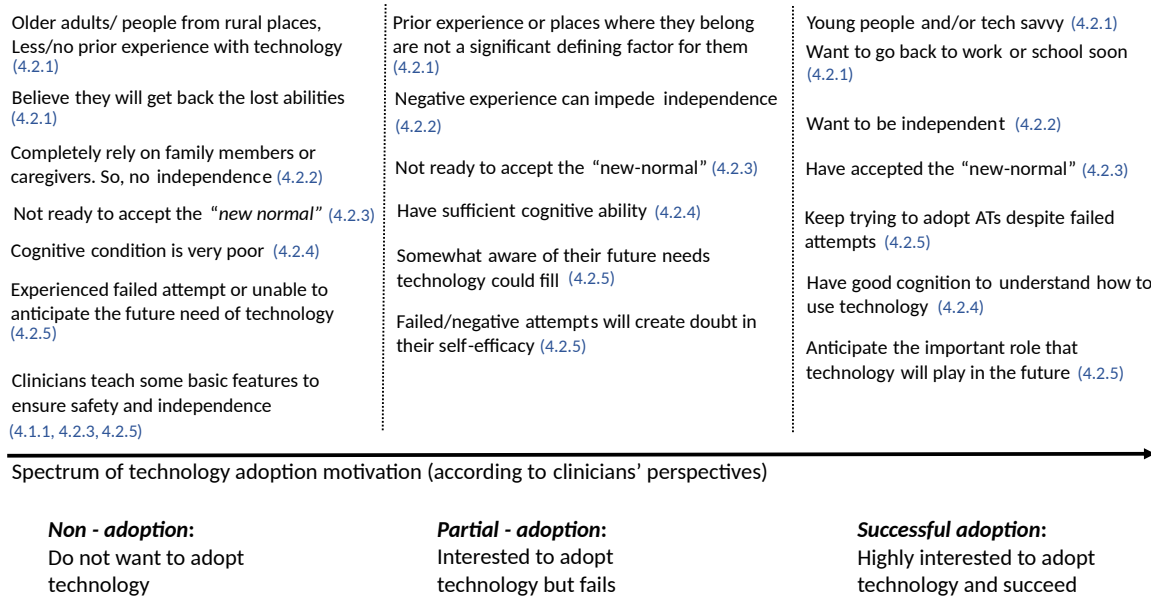


Fig. 2. A synthesis of clinicians' perspectives on the different motivations individuals may have for adopting technology soon after sustaining a severe spinal cord injury. We define levels of *non-adoption*, *partial-adoption*, and *successful-adoption* in the spectrum of technology adoption motivation.

factors (Section 4.2.4); and (6) frustrated following a failed attempt or unable to anticipate the future usability of the technology in post-rehabilitation life (Section 4.2.5).

In contrast, individuals who have **high motivation to adopt ATs** fit one or more criteria from the following. They are: (1) young and/or tech-savvy people who have a baseline motivation to use new technology (Section 4.2.1); (2) are eager to return to work or school (Section 4.2.1); (2) eager to be as independent as possible (Section 4.2.2); (3) accepting of their "new-normal" (Section 4.2.3); (4) determined to adopt new technology despite prior failed attempts (Section 4.2.5); (5) cognitively capable of understanding technology usage instructions (Section 4.2.4); and (6) anticipating their future needs for technology in post-rehabilitation life (Section 4.2.5).

The people in the **middle of the spectrum** are the most vulnerable because they are interested in adopting ATs, but they might move to the non-adoption side of the spectrum due to negative interactions or experiences. Our findings suggest that typically, they: (1) are not predisposed towards or away from technology usage based on age, prior experience, or location (Section 4.2.1); (2) have sufficient cognitive function to understand technology usage instructions; (3) are somewhat aware of their future technology needs in post-rehabilitation life (Section 4.2.5); (4) may shift toward the non-adoption category due to negative experiences or failed attempts because it will cause them to doubt their self-efficacy; they might not try again and will have a rejection mentality for that technology (Section 4.2.5); (5) consequently fail to build independence (Section 4.2.2); and (6) are not fully accepting of the "new normal" due to a refusal to accept that they cannot regain their former abilities (Section 4.2.3).

Thus, individuals' motivation to adopt AT during rehabilitation varies widely depending on many factors. Our findings do not tell us precisely the mechanisms that might cause a person to move up from non-adoption to

partial adoption, nor do they illuminate if people in the successful adoption category might move down. However, we can speculate that some factors, such as cognitive ability, a desire for independence, or a growing acceptance of the new normal, may help people in the non-adoption category move towards adoption. Similarly, an adverse change in those factors could lead someone away from successful adoption, although this seems less likely. The partial-adoption category suggests the most potential for change: the success or failure of early adoption attempts seems to be an important factor. In the next section, we further discuss the importance of considering those factors in technology design.

5.2 Technology adoption after sustaining an SCI: not one-size fits all

Any negative interactions that an individual might have with ATs during the rehabilitation period—soon after sustaining the injury—can adversely affect their overall adoption of technology and their adjustment to post-SCI life. For instance, our findings (Section 4.1 and Section 4.2.5) illustrated several challenges individuals with recent SCIs encounter with ATs, including using complicated functions of a PWC or voice-to-text features to operate a mobile phone. Such negative interactions might be a result of the way contemporary AT design treats motor disabilities as a monolithic group, and does not take into account that people with a severe SCI often simultaneously acquire multiple disabilities [38, 44, 52].

One explanation for negative or unsuccessful experiences with ATs impeding adoption is that those experiences likely negatively impact individuals' self-efficacy [20] and result in self-doubt, particularly for people who are partial- or non-adopters (see Figure 5.1). Indeed, During rehabilitation, a person's self-efficacy plays a vital role in their adjustment to post-SCI life, as well as their mood, pain, and quality of life [19, 20, 40]. To make their adjustment to post-SCI life as smooth as possible, it is important to think about their disability experience holistically. Here, we highlight Frauenberger's critical realism lens of disability [29], which argues that ATs should not only mitigate functional limitations or eliminate social barriers; instead, it should perform more than just accomplish tasks (navigation, information access, etc.) with a clear understanding of how it will interact with all levels of their disabled experience.

Further, informal caregivers—often family members or friends—are also impacted by sudden traumatic SCIs of their loved ones. In addition to emotional impacts, they must also learn about the injury and how to support the injured individual. However, they play a critical role in facilitating technology adoption soon after the individuals sustain an injury. Buyuktur et al. [9] highlighted the importance of caregiver assistance during post-SCI rehabilitation in preparing individuals for self-care activities. Our study expands on this by emphasizing that caregivers play an integral role in setting up, troubleshooting, and operating ATs together with the person with the SCI; this is essential for physically and emotionally preparing individuals with newly acquired disability to adopt the technology. Notably, caregivers' technology literacy and preparedness, including their ability to troubleshoot and set up technology, are crucial factors in providing support to individuals with an SCI. Contemporary HCI research recognizes the importance of incorporating the perspectives of informal caregivers in the home settings into the design process of ATs [6, 47, 55]; however, their experience and perspectives in the rehabilitation hospital often gets lost [47]. Thus, exploring ways of including caregivers in the design of ATs for the early rehabilitation period of individuals who have recently acquired a disability is an exciting opportunity for future research.

5.3 Transitioning from *patient* to a *person with disability*: not a simple story of “then” versus “now”

The results of our study show that adopting new technology after sustaining a severe SCI is not a straightforward process. Instead, this depends on the individual's ability to accept the transition from “being a patient” to being “a person with a disability” upon leaving a rehabilitation hospital. In particular, technology adoption heavily depends on accepting the “new normal”, which requires accepting the new set of abilities, new self-image, and identity beyond the simple transformation of “then” versus “now”.

Prior HCI literature has acknowledged the dynamic and continually transitioning nature of people's lives [26] and its impact on their technology adoption. Notably, transitions in life impact people's use of technology as they adjust to new circumstances and new identities [10]. That means, in our study context, the identity transition from "a person without a disability" to "a person with a disability" has a significant impact on their acceptance of technology [43], because this transition causes them to re-evaluate their perception of the ease-of-use of the technology, its usefulness, and their capabilities to use them. Our study extends prior work by finding that adopting new technology in the rehabilitation hospital appears to be associated with prior experience of using technology (section 4.2.1), anticipation of future need (section 4.2.5), perceived availability of external support (section 4.2.1), and desire for independence (section 4.2.2). These factors likely impact initial intentions regarding technology adoption, but they are then further impacted by the experiences individuals accumulate over time, including the process of setting up, learning, and troubleshooting the technology (section 4.1.3), and the response time (section 4.1.4) during the interaction between the user and the technology.

To foreground these factors and conceptualize our findings of individuals' technology adoption in a theoretical framework, we adopt Venkatesh's extended version of the Technology Acceptance Model (TAM) [65] (See Figure 3). While Davis' Technology Acceptance Model (TAM) [21] described a user's behavioral intention to adopt a technology using two factors: (1) perceived ease of use, and (2) perceived usefulness; Venkatesh [65] extended TAM framework by including an anchoring and adjustment perspective with the perceived ease of use. According to that extended TAM model, as the interaction experience with an intended technology increases, individuals' perceived ease of use is shaped by an *anchor* and a corresponding *adjustment*. The *anchor* represents how users view technology in general. It includes user perceptions of control, external control, intrinsic motivation, and emotion that determine how easy it is for the user to use the technology. *Adjustment* is determined by objective usability and perceived enjoyment. We conceptualize the factors from our findings and map them to these extended TAM framework constructs below, showing how they impact the perceived ease of use of technology (see Figure 2):

Anchors are what users generally believe about technology: the amount of control they have, the amount of external control it has, their motivation, and the amount of emotion involved with the usage.

- (1) *User's control*: Users' perception of their self-efficacy and control, including the availability of knowledge, resources, and opportunities required to use new technology. Here, we conceptualize users' control as prior experience with technology (Section 4.2.1), and anticipation of future needs (Section 4.2.5).
- (2) *External control*: The influence of the surrounding environment. We consider external control as the instructions of the clinicians (Section 4.1.1), and users' perceived availability of support from family members and caregivers (Section 4.2.2).
- (3) *Intrinsic motivation*: The perceptions of pleasure and satisfaction from using the technology. One dimension of intrinsic motivation is individuals' intention to adjust to the "new normal" (Section 4.2.3) and achieve independence (Section 4.2.2).
- (4) *Emotion*: The user's emotion refers to an individual's apprehension, or fear/anxiety regarding prior experience stemming from "anxiety with technology". Here, we adopt emotion as the negative prior experience that results in a lack of self-efficacy (Section 4.2.1).

Adjustments: As users gain experience, their perceptions regarding the ease of use of the intended technology change. This construct defines those changes after using the technology.

- (1) *Objective usability*: The effort that is required to utilize a technology. We conceptualize objective usability as required efforts for operationalization (Sections 4.1.3, 4.1.5), such as set up and troubleshooting, perceived response time of the technology interaction (Section 4.1.4).

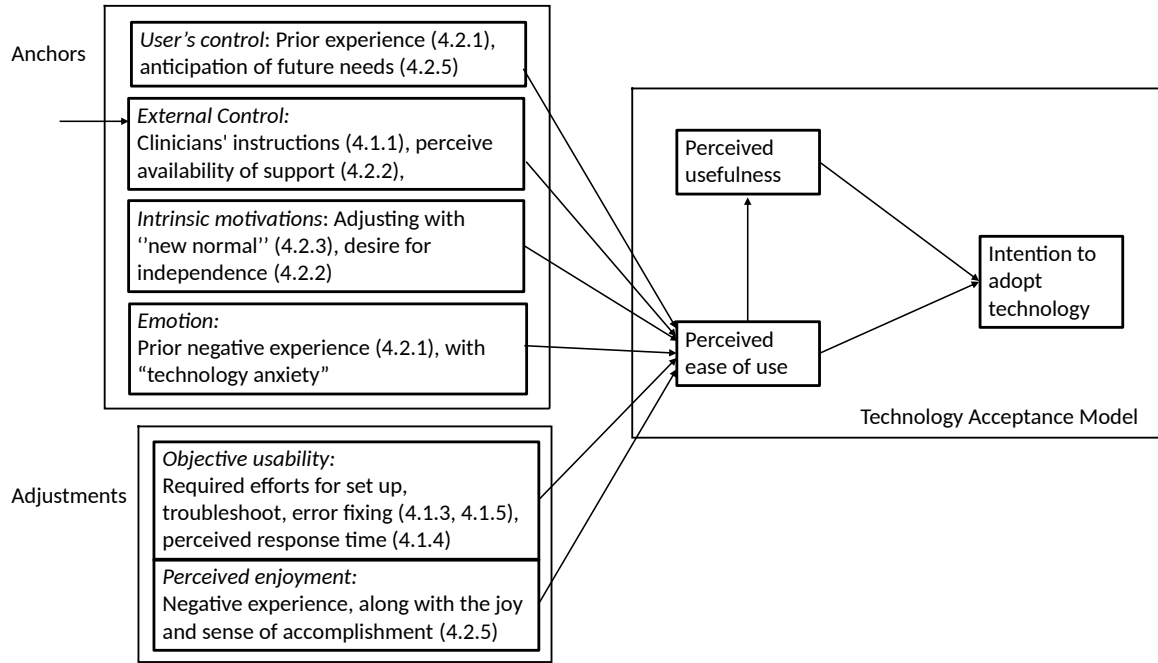


Fig. 3. We conceptualize our study findings through Venkatesh's extended version of the Technology Acceptance Model (TAM) [65]. We map *Anchors* and *Adjustment* constructs of this framework, that impact the perceive ease of use of technology by the individual with a severe SCI.

- (2) *Perceived enjoyment*: How much users perceive that they enjoy using the system. We consider perceived enjoyment as a negative experience, but also with the joy and sense of accomplishment that can come along with successful attempts with a technology (Section 4.2.5).

Thus, according to the extended Technology Adoption Model, the factors of "anchors" refer to an individual's predisposition to technology, which is intrinsic, and varies from person to person. Thus, these factors are beyond the control of AT designers but could still be accounted for in the designs. The factors of "adjustment", including objective usability and perceived enjoyment, are crucial in designing usable ATs for successful technology adoption, soon after sustaining an injury.

To make ATs more usable by easing the objective usability and perceived enjoyment to help individuals in adopting ATs, here we provide recommendations to improve the adoption process and design of AT for individuals, who have recently sustained a severe SCI:

- **Introducing ATs :**

1. Assessing individuals' prior experience with technology with the help of their family members or informal caregivers, soon after being admitted to the rehabilitation hospital
2. Introducing assistive technology to the individuals according to their prior experience level for the first few weeks. For instance, not introducing the features of mobile phones to people with no/less experience with mobile phones, until: (a) they overcome the initial trauma of the injury; (b) their voice gets strong enough, if they have speech impairment; (c) if they have respiratory challenges, avoid introducing any technology that requires voice-to-text interaction.
3. Introducing ATs that individuals will be most likely successful to adopt earlier, so that they can build up

enough confidence, instead of getting stuck or too entrenched with a particular technology. Once, they start building up self-efficacy, then other technologies can be introduced slowly.

4. Scaffolding early introduction to ATs through more accessible interactions; for example, introducing voice-to-text through a training system with a reduced number of commands, or using a customized microphone so that they do not need to put additional effort or strain too loud for their voice to be detected by the system.

- **Including caregivers in the adoption process:**

1. Prior to offering training to individuals who have recently acquired an injury, it is essential to provide initial training to caregivers regarding PWC or room control.

2. Informal caregivers might have limited technical knowledge for setting up or troubleshooting technology. It is important to include them in the training process and providing concise resources for ATs, especially for emergencies.

3. The informal caregivers can be trained for the emotional work [61] that they need to provide to the injured individuals by supporting them in the face of the “new normal.”

5.4 Facilitating self-tracking with new tracking needs

Our findings revealed that self-tracking practices and needs change significantly for individuals with severe SCIs. According to the clinicians’ observation, individuals who were involved in tracking various personal health data had stopped tracking them after sustaining the injury (section 5.4). This is mainly because they can no longer track many of the aspects they previously tracked (e.g., counting steps [12]). Further, the new aspects they need to track (e.g., bladder/bowel management, pressure relief tracking) after sustaining the injury are not supported by tracking tools [9, 52, 53]).

Prior research on personal informatics explored several reasons for the abandonment of self-tracking practices, including finding success [56], no longer feeling the importance of tracking [15], becoming frustrated over time-consuming tracking [17], and it not being worth the time investment [42]. In addition, Epstein et al. [27] summarized reasons why people stop tracking, including the scenario of “life circumstances change” that lead to the forced abandonment of self-tracking. Most of the situations they considered were temporary (e.g., pregnancy) or did not significantly impact most aspects of life (e.g., stopping running and starting other exercises, stopping riding bicycles due to an injury). Similarly, in their recent work, James et al. [37] explored the impact of individuals’ sudden life changes due to Type-1 Diabetes and the process of initial disruption to rebuild self-care practices with a new lifestyle and support networks. They demonstrated the importance of designing technology that can adapt to dramatic events or life transitions so that individuals do not have to add additional cognitive load to their self-management system.

However, in traumatic life-changing circumstances like sustaining a severe SCI, people permanently lose multiple bodily functions, and they are unable to track most of the aspects they used to track before, as well as not interacting with tracking tools (e.g., Fitbit, smartwatch) as they were previously able to. Additionally, people need a different set of self-management and self-tracking practices in post-SCI life, including tracking of pressure reliefs, catheterization, bowel management, and medication, which have largely been ignored in prior PI literature. Although research has explored quantifying some aspects of manual wheelchair users’ activity like fitness or physical activity [31], other aspects of PWC users are under-explored. In a review of PI research, Motahar and Wiese [53] identified that prior research almost completely ignored the population with severe motor disabilities.

Recently, self-care technology designers have focused on and prioritized individuals’ challenges with self-care activities—that they need to adopt after an SCI—and the need for tracking technologies to improve adherence. [8, 52]. Similarly, Li et al. [45] highlighted the importance of relevant tracking technologies for PWC users, particularly those with upper-body impairments. Corroborating that line of work, our work advocates expanding the focus

for people whose functional abilities are abruptly lost due to traumatic events. That also includes adjusting the interaction mechanism according to individuals' level of disability. For instance, individuals with limited upper body functionality should transition from wearable to chairable [13] data collection. This involves integrating sensors into PWCs, such as, underneath the seat-cushion, foot rest, or with the joystick to streamline the data collection, which will reduce the burden of self-reporting [37]. Similarly, the wheelchair screen can be used to deliver self-tracking data (e.g., number of accomplished pressure reliefs, next catheterizing schedule) which will help the individual improve their new self-care behaviors. Thus, future personal informatics research needs to go beyond the traditional self-tracking practices and expand on how technology design should incorporate the "life after transition." Researchers should consider the affordances of tracking technology that would accommodate users' varied tracking purposes, accommodating users' post-SCI tracking needs by incorporating pre-injury data tracking practices.

6 CONCLUSION

Designing effective technology for seamless adoption, particularly for users with diverse abilities, is crucial for HCI researchers. In this paper, we investigated the complex and multi-faceted process of technology adoption soon after individuals sustain a severe SCI. Through the perspectives of individuals who have had a recent spinal cord injury, their caregivers, and rehabilitation clinicians, we explored the broad spectrum of individuals' technology adoption motivation; the challenges they face to adopt those technologies; and clinicians' efforts to mitigate the challenges and help individuals adopt technology to some degree to ensure independence and safety, irrespective of their motivation. Our findings contribute to future technology design guidelines for people who lose significant physical abilities, so that they can seamlessly adopt ATs to have an easier transition from "a person without disability" to "a person with a disability."

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